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Analysis of body movements for development of male wheelchair tennis shirt

Heejae Jin
Oregon State University

Kathy Mullet
Oregon State University

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Heejae Jin, Kathy Mullet, Oregon State University, USA

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The purpose of this study was to analyze body movements to examine clothing fit for wheelchair tennis players. To determine the range of movement of the arms and torso of male wheelchair tennis players, manipulative tasks (Hutzler, 1986) in wheelchair tennis were applied for the body movements. In the Hutzler's taxonomy (1986), manipulative tasks consist of arm and trunk movements using the wheelchair as a sitting platform. Prior to developing clothing for wheelchair tennis players, body movements were observed. Garment strain was observed during the body movement using manipulative tasks.

Analysis of body movement

For this study, the analysis of body movements was based on the Watkins's method (1995). Through training films, observations can be made to determine strains on garments or fabric stretching occurring during movement (Watkins, 1984). To analyze body movements, processes were to:

1. Select the appropriate wheelchair tennis training video: Using YouTube, two videos were selected. One is to observe the chair movement, forehand, and backhand position using keyword as "wheelchair tennis training". The other is for serve position through keyword "wheelchair tennis training serve". In order to observe sufficiently, those videos were selected within the top 3 of the YouTube search, and were 2 to 10 minutes of length. In addition, to watch effectively, videos were considered individual training instead of match play games;
2. Observe the training video: The research team observed where strain on player's garment through arm or trunk movement in each tennis skill. Since the purpose of functional clothing is to enhance of performance, movements to reach the ball were analyzed. That means that body movements were not considered the posture to prepare to stroke the ball, including the grip of the racket and positioning of the wheelchair; and
3. Code of body movement type: whenever garment strain occurred through arms or trunk movement to reach the ball, body movement types were coded in each tennis skill. During the video, pause and play were repeated to capture the image of body movement type. However, the movement that was already captured was not considered again.

Validity and reliability

For effective observation, face validity was established: the categories of body movement related to garment strains were agreed through the researcher team who had research backgrounds in apparel design and body movement analysis. Through several meetings, the researcher team modified the operational definitions and eliminated the categories until the final categories were determined.

For consistency, the same training video was observed by both researchers. To estimate reliability between the researchers, inter-observer agreement was used the following formula:

IOA = agreements /(agreements + disagreements)
The reliability of coefficient was estimated 0.86 as the moderately high is range from .80 to .89.
The result of observations for the analysis of body movement is shown table 1.
Table1. *Body movements related to garment stress*

Categories (Tennis skill)/ Units		Operational definition body movement related to garment strain	
		Body movement	Garment strain
1.Forehand		For this position, racket swing from a low to high position and start to the racket with extended arm and should be rotated shoulder away	
	1-1. racket with extended arm at the low position	To make contact with the ball, racket should be back and then contact the ball	The front trunk with the diagonal wrinkles
	1-2. arm follow though high swing	The dominant shoulder should be rotated away the net	The sleeve (arm) with horizontal wrinkles, the diagonal wrinkles of the front trunk and scapular
2. Backhand		This is backhand shot. Players shift weight toward the ball	
	2-1. racket back high or low	Racket is back to reach the ball toward non-dominant arm	The sleeve with horizontal wrinkles and back trunk with horizontal wrinkles
	2-2. follow through high	The extended elbow to follow though high in the air	The vertical wrinkles on the shoulder and the front trunk with diagonal wrinkles
3. Serve		From tossing the ball to contact the ball with moving up the racket	
	3-1. reach the toss	Toss the ball and hand with racket should be moving up toward back fence depend on shoulder level	The vertical wrinkles on the shoulder, the front trunk and sleeve with diagonal wrinkles
	3-2. contact the ball and follow through	Contact the ball with full extension, then arm follow down around the opposite side of body	The horizontal wrinkles on the front trunk and sleeve
4. Push Chair		Move to a ball, to react to get the ball, and to hit the ball	
	4-1. forward propulsion	Move towards ball and hand should be on the push rim. Hands and elbows forward and down with trunk flexion forward	The horizontal wrinkles on the front trunk

The analyzed body movements related to garment strains will be applied to improve fit issue for wheelchair tennis shirt and to evaluate the fit effectiveness at each movement.

Reference

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